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Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

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Resins for Tube Bending

ONE of the minor industries in this very industrial world is that of metal tube bending and coiling. If the total length of tubing made in this country were put end to end, it would reach a long way, no doubt, for an aircraft contains dozens of yards of it, motor vehicles must have it. Tubing is used for heating and also for condensing. Tubing is almost always curved or twisted or spiralled and the curving, twisting, or spiralling must be carried out so that the tube, which may vary from $\frac{1}{16}$ in. to, say, 2 ins. diameter, does not split or wrinkle during the bending operation. Wrinkling at the inside bend is obviously almost as bad as a split, since the flow, and therefore pressure, of the conveyed liquid is reduced.

The method of bending tubes is as interesting as it is fascinating to watch. To prevent collapse of the tube during the operation it is filled with a closely packed material, one that can be readily removed after the operation and for the sake of economy one that can be reused as large a number of times as possible. Thus sand is an old favourite, with two plugs in the ends of the tubes to keep it in place. Rosin has long been used, while the newer arrivals are compounds, such as the synthetic waxes, and the very low-melting-point bismuth alloys which fuse at about 100 degrees C. All these are melted, poured into the tube and allowed to set hard. When the tube has been bent, it is heated to melt the "matrix," which can be reused a number of times, dependent on its character.

None of these compounds works perfectly satisfactorily in all cases. Most organic substances have high coefficients of contraction, so that, like ordinary paraffin wax, a hole is formed in the material on cooling, introducing weak spots in the structure. Splitting of the metal tube then occurs. Likewise, brittle substances such as pine rosin are not very satisfactory. It is certainly true that each change in wall-thickness, in diameter, in angle of bend, and in change of metal brings its own problem.

Theoretically speaking, water would probably be an ideal material to use, if only it could be contained in the tube under pressure. This, however, is almost impossible in mass production. It would seem, on the whole, that there is here a field for physical and chemical research among the synthetic resins, especially those of the polymerized type. What is required is a hard and strong, but not brittle, substance. It must be capable of being melted at a low temperature, say 100 degrees C. to 150 degrees C., and remelted a reasonable number of times before it loses some of its properties and must be discarded. Obviously, the thermosetting resins cannot be considered. As indicated already, certain easily melted polymers might prove suitable, especially if they have not a sharp melting point. In other words, the crystalline type is probably not as suitable as the non-crystalline kind, for the latter is probably less likely to shrink and form "blow-holes" during cooling.

A new type of resin is now being tested for the purpose in a London works. It appears to possess many of the above characteristics, accompanied by an extraordinarily high "wetting" power; that is, it sticks tenaciously to the metal surface. The greater part is removed after bending by melting and any residue is removed by simple immersion in white spirit or paraffin.

A Problem in Meat Storage

ONE of the major problems that has arisen in wartime is the frozen storage of meat and the deterioration that occurs during a period that can extend to six months or longer. At the low temperatures employed, about 0 degrees F., microbial activity ceases, but deterioration can still take place because of surface drying or "freezer burn." This is brought about by the extremely low humidity in freezers, the moisture being gradually removed from the meat to the brine coils, which are some 10 degrees colder than the surrounding air. The deterioration occurs in all meats but is most easily seen in poultry.

Recent research in Gt. Britain has tackled the problem from two points. One is that of humidifying the freezers so that no moisture is taken from the meat. Some success in this process has been reached on laboratory scale, but it is not yet used in practice. Commerce makes use of moisture-resistant wrapping and packages for protec-

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tion against surface drying. Investigations have shown that, in order to be effective, a reasonably moisture-resisting wrapping must be used and that the wrapping must be sealed. Although nearly all wrappings can be sealed, many cannot be sealed with sufficient ease to make this practice commercially feasible on most meat products.

Perhaps the best method of moisture-proof wrapping is the rubber latex bag. This combines moisture-proof material with easy sealing, and practical absence of internal air pockets even on quite irregular-shaped products. New plastic materials applied in liquid form also offer promise, but have not yet been used.

The last-named method would appear most interesting to the plastics industry, and presumably liquid latexes of rubber and rubber-like materials, such as the polyvinyl chlorides and their co-polymers with the "acrylic" type, or, alternatively, their solutions in highly volatile solvents are indicated. Both dipping and spraying processes could be very conveniently applied.

BUILDING FOR THE FUTURE.—On page 169 of this issue a young architect, George Fejér, who has already contributed to this journal (October, 1940) on the interesting cellulose acetate structure known as Isol-umen which he helped to develop for architectural purposes, gives us his ideas on some of the methods he would adopt in building construction using transparent or translucent sheets modified, for insulating purposes, into cellular form.

Isol-umen, it will be remembered, consists in structure of a corrugated sheet of acetate cemented on another sheet or between two sheets of the flat material. He now suggests that for roofing and other exterior glazing the polystyrenes and polymethacrylates, which have such high water resistance, should be also employed.

What will come as a shock to most plastic workers, however, is the suggestion that these substances should be extruded into the cellular sheet. It is a daring suggestion, and if we may put it, even too daring for modern technique. Modern extrusion of simple tubes 1 in. in diameter is difficult enough. The extrusion of widths of, say, 2 ft. seems quite out of court with modern machines. The problem of keeping the cellular structure from collapsing on issuing from the die would be a major one.

In spite of this we welcome Mr. Fejér's notes. He is one of the very few architects in the country who have taken the initiative in attempting to interest the architect in plastics and bring about a greatly desired collaboration between architect and plastics manufacture.

FORD'S PLASTIC CAR.—As forecast in our issue, Mr. Ford has made a completely plastic car, that is all except the frame, engine and wheels, and it is now on exhibition at Dearborn. "The Times's" New York correspondent gives the following information. The plastics used are cellulose combinations from farm products, such as wheat, cotton, maize and soya beans, with resin as a binder.

> "The plastic panels of his car, though only $\frac{3}{16}$ in. thick, can take a blow 10 times harder than steel can without denting. Plastics are inferior to steel only in tensile strength. The weight of the experimental car is 2,000 lb., which is only two-thirds the weight of a steel car of the same size, and even this weight, it is said, can be reduced without any sacrifice of strength. Plastics cost more than steel to make, but require fewer fabricating and finishing operations, so that plastic cars can be turned out not only more economically but more rapidly than steel cars. Moreover, being lighter than steel cars and at the same time tougher, they will cost less to operate."

We hope we will not be accused of high treason, but we wish "The Times" would not use such loose expressions as those contained in the first few lines of the above note.

Plastics for the Amateur

IN our July issue on our "Inquiries and Answers" page we intimated that the American book "Plastics in the School and Home Workshop," by A. J. Lockrey, would shortly be published in this country by Chapman and Hall, Ltd. We have just received our review copy and hasten to add our measure of praise at the appearance of this excellent and illuminating book.

It is also an important book, important to the educational system and important as an exposition of new materials for expression both by the amateur and professional artist. There can be little dissent that schools have, in plastics, new and colourful media for forming the minds of the young, for giving them an appreciation of beauty, and for teaching them the use of the hands and simple mechanical tools. In this country the use of plastics in schools has only just begun, but we hope that movements such as were commenced by Mr. Woodiwiss, described in our May, 1939, issue, and by other workers, will spread quickly after the war. Mr. Lockrey tells us that there are hundreds of schools that include plastics in their craftwork in the United States and that thousands of amateur craftsmen are fashioning articles by hand and machine from these gemlike materials.

The opening chapter of the book, under the title of "A New Crafts Material," describes what plastics are, how they are made, and in what form they can be bought by the craftsman. It is somewhat significant that phenolic cast resin in rod, tube, sheet or special cast forms seems to be the pet working material of the author. In the original first edition he apparently did not include special chapters on acetate or methyl-methacrylate resin. In this first English edition (second American) excellent chapters on these are included.

Chapter II deals with the equipment required and includes very detailed descriptions of both hand and power tools, illustrated by detailed drawings and photographs. This is followed by careful descriptions of the methods of carrying out the various operations with them: drilling, sawing, shaping, grinding, milling and turning. A separate chapter elaborates what the author calls the real adventure in working plastics, namely, carving; and to complete the section on equipment and methods there are accurate details on cementing, embossing, in-laying and finishing processes. Furthermore, the author is sufficiently up to date to include the new casting processes using rubber moulds.

There are innumerable tricks of the trade which are shown to obtain new or artistic effects which interest and amuse the reader, e.g., the curious but clever ways of making rings, the methods employed for getting two colour effects in one casting, and of dry-point etching on celluloid. The photograph showing a dressing table carved out of methyl-methacrylate resin by an American lady designer, which sold for over £250 is an excellent example of the beauty of plastics.

Among the final chapters are those under the title of "Hand-tool Projects and Power-tool Projects." These sections deal analytically with a large number of definite objects. Thus, the student is shown how to make a cigarette box or a chess set by describing the exact method to be adopted and what special precautions are to be taken. All this is accompanied by accurate drawings.

There is little to criticize in this work because of its general excellence, and because Mr. Lockrey so obviously knows his job. Nevertheless, we are sorry to see that casein, one of the loveliest and, what is so important to schools, cheapest of the plastics, is not included. He dismisses this plastic by saying "Caseins, for example, warp in any sheet over 4 ins. square and take up water, as they remain, for all practical purposes, organic material." What the last part of this sentence means we are not at all clear. We are under the impression that all plastics are, and "remain," organic material.

Plastics and Powder Metallurgy

By H. W. GREENWOOD

Being further notes on the incorporation of metal powders in plastics and the changes wrought thereby. In this issue the writer deals with their application to laminated plastics

IN previous articles the question of incorporating metal powders in pure plastics has been considered and some of the possibilities noted. By pure plastics is here meant plastics without fillers or in which metal powder alone supplied the filler. One large class of plastics has not been touched upon, namely, the laminated plastics. This apparent neglect has been deliberate because when the possibility of utilizing metal powders in the plastic industry was first discussed it was with a view to the metal powders modifying in some favourable direction the properties of the pure plastics and so widening the field in which they could find application.

The moment one considers laminated plastics one is dealing with materials having some physical properties in marked contrast to those of pure plastics. It would be no exaggeration to say that among the laminated plastics there are some materials which compare not unfavourably with some of the metals. If we compare the tensile strength of pure plastics with those of metals plastics are inferior and the same is true of the modulus of elasticity. A consideration of such properties would at once rule out the possibility of substituting pure plastics for metals. With laminated plastics it is another matter and they have perhaps rather more application in engineering than many people suspect.

The Problem Applied to Laminated Plastics

That being so it should be of interest to consider whether there are possibilities of value in incorporating metal powders in laminated plastics, if so how they should be incorporated and to what particular end. This will involve a knowledge of the directions in which laminated plastics are used in engineering, the problems which their introduction tended to solve, what problems their use has, in turn, given rise to, and if the incorporation of metal powders can help by conferring upon the laminated plastics any new properties which they do not possess.

It will be reasonably obvious that there is little advantage to be obtained by using metal powders in laminated plastics placed in static positions such as panels, divisions, etc., commonly employed in the electrical industry. Here the essential properties of the laminated plastics are perfectly suited to the services that are required of them and the addition of metal would militate against, rather than assist in their functioning.

Where the use of metal powder is likely to prove advantageous in conjunction with laminated plastics is in moving parts and particularly in those situations where moving contact must take place as in gear wheels, idler or other pulleys, ball-bearing races and, above all, in heavy mill bearings in plant such as rolling mills where laminated plastics have achieved no mean success.

The Value of Plastic Bearings

It is quite unnecessary here to speak of the many advantages of laminated plastic bearings, the mill industry is as well aware of them as the plastic industry itself, but it may be permitted to draw attention to one or two points which have a direct bearing on the possibility of using metal powders in such bearings.

In particular, laminated plastics in such situations have shown good load-carrying capacity coupled with low modulus of elasticity which minimizes high concentration of load, low coefficient of friction, and low thermal capacity. Nor should the fact that under heavy load a very smooth bearing surface can develop be overlooked in relation to what is going to be said regarding metal powders.

Past Experience with Graphite, etc.

It will be known that in connection with moulded plastics in which rubbing contacts were involved, graphite powder has been incorporated in the moulding powder and the resulting mouldings have given a good performance. This was the earlier experience of the rubber people when confronted by a like problem with their own materials. They also made use of lead powder under similar circumstances with such success that the process was protected by patent. It is not unreasonable to suggest that the use of lead or pure tin in the outer layers of laminated plastics might be a very real advantage. Their presence would in no way interfere with the normal functioning of a heavy duty bearing, for the separate particles of metal would be of such an order of size, less than 50 microns in diameter, that they would not interfere with the movement of the skin of the laminated plastic necessitated by the settling down of the surface layers to a smooth bearing surface. Yet they would tend to provide a metallic and a lubricating face to the bearing and help toward better mechanical conditions than those provided by the plastic alone. At the moment it is not necessary to raise questions of heat conductivity, because a mere metal skin would hardly produce a very appreciable effect; moreover, we know that the laminated plastic bearing has proved successful notwithstanding its poor heat conductivity. Where it is likely that the use of metal powder may prove advantageous is in helping to solve one of the rolling mill engineer's problems, namely, slip, particularly in the case of friction roll drives. Already the use of laminated plastic bearings has helped in this direction and it has been shown that notable improvements can be obtained by lubricating with emulsion. There is a real probability that a very thin metal facing here, produced by impregnating the skin of the plastic bearing with metal powder, might bring about a decided improvement. There is also the practice recently introduced into German rolling mills of using synthetic resin collars which press against the ends of the barrel of the rolls. This is another contact surface which conceivably might be improved by a metal skin in situ.

In all these cases the metal powder should be introduced into the outer layers of the laminated plastic. Whether the plastic is moulded to form in the first

place, or cut as is the case with the silent laminated plastic gears, the application of the metal powders to form a surface skin does not offer any serious difficulty. What is important is that when the work is done it shall be carried out under very careful laboratory supervision and with such safeguards as to ensure that the data obtained will provide a trustworthy basis upon which to decide the degree of advantage the use of metal powders offers. It should be remembered, in this connection, that there has been something little short of a revolution in the method of using anti-friction metals in the past few years and that to-day metal layers, only a few thousandths of an inch thick, have replaced the cast-metal liners of not so very long ago. This may be considered some encouragement for the view that useful results should accrue from using very thin metal layers on surfaces in rolling contact, as also the fact that both graphite and metal faces have been developed with success on the mechanical side of the rubber industry.

From the powder metallurgical side it must be pointed out that there are almost innumerable possibilities available as to the metals, alloys and other metal combinations which can be produced in powder form. Should the method prove of general application there does not seem to be any reasonable specification for which metal powders will not be forthcoming. That being so it will be appreciated that the first steps should be taken in such a manner as to ensure that the conditions for comparatively simple cases are investigated thoroughly to begin with.

In view of the ever-widening prospects for the application of laminated plastics, and having in mind some of the difficult problems they have already solved with no small measure of success, it does not seem an exaggerated hope to expect increasing advantages from a wise use of metal powders with laminated plastics. The more one studies parallel lists of the properties of metals and the properties of plastics the more the conviction is driven home that wider syntheses involving these two groups of materials will lead to notable advances and to the solution of many problems which to-day are either unsolved or only solved in an unsatisfactory and uneconomical manner.

Shellac Formaldehyde Resins

THE possibility of the development in India of a plastics industry based upon the materials containing both shellac and synthetic resins was discussed by Dr. H. K. Sen in an address to the general meeting of the Indian Chemical Society at Benares. The address was published in the "Journal of the Indian Chemical Society" for February, 1941. Whilst, said Dr. Sen, the production of synthetic plastics is dependent on an all-round industrial development, the existence of the natural resin shellac raises the question whether this unique raw product could not be the basis of a commercially feasible plastics industry, i.e., in reasonable competition with synthetics. Statistics show that the demand for shellac has steadily increased, and, in fact, from an export figure of 308,937 cwt. in 1920-21, it stands at 760,399 cwt. in 1939-40, in spite of the tremendous output of various synthetic resins in the countries importing shellac. About 11,000 tons of shellac are consumed by the gramophone record making industry, into which synthetic resins have scarcely been able to penetrate. It is hoped that the attention of the State will be directed to an inquiry whether a plastics industry based on India's natural products cannot be developed, and, if so, what steps it should take to bring such an industry into being.

If shellac compositions are to be more widely used for plastic moulding, they should be capable of being produced at a faster rate than by the hot and cold process, and should be much more heat and water resistant than the gramophone record compositions. Recent investigations at the Indian Lac Research Institute have shown that shellac, modified by formaldehyde, urea, melamine, etc., can be worked by the hot moulding technique, and shellac modified with formaldehyde and guanidine carbonate filled with jute waste can be injection moulded. The heat resistance of the modified shellac moulded articles is about 90 degrees C., and is, therefore, suitable for most purposes. By gradual afterbaking the resistance can, however, be raised to 120 degrees C. and more. The theory underlying the modification of shellac by formaldehyde is as yet obscure, but there is sufficient evidence that the interaction gives rise to a shellac formal. On heating shellac with formalin for 1-1½ hours, subsequent washing of the product with several changes of hot water, a formal derivative containing 4-6 per cent. formaldehyde is obtained which liberates formaldehyde on keeping only slowly. This formal is more plastic than is shellac itself, and has a softening point of 68 degrees C., about 10 degrees C. lower than shellac. The chief characteristic of the formal is its slower polymerizability.

Components for Aircraft

READERS will remember that in our July issue we gave notice of the fact that an important plastic exhibition would be held on July 23 at Grosvenor House by the Society of British Aircraft Constructors. As the exhibits shown were to be, in the opinion of the Society, of a highly secret nature never before seen by man, no outside eye, as typified by the public and technical or trade Press, was allowed to enter the building. From general reports it would seem that little was shown that is not known already to the readers of this journal. An interesting description of one of the new materials, Pytram—of which little has been heard—has appeared in an article by Dr. Yarsley in the August issue of "The Times Trade and Engineering Supplement."

It is a cellulose fibre material bonded with special-type adhesives on the laminated principle. The natural inherent resilience resists indentation and the very nature of the material suggests that, in fatigue under vibration, it has qualities superior to other materials commonly used. The initial difficulty of the effects of weather on this synthetic material has now been overcome. The material has many of the characteristics of metal and light alloys, is light in weight, strong and resilient. The original strength and fibre orientation of the material are retained, and, as compared with metal of a similar weight, it is much less likely to suffer accidental denting and other impact damage. Shapes of all types, with complicated double-curvatures, can be easily and cheaply produced in large or small quantities. The moisture resistance of Pytram is adequate for most purposes, and obviously there can be no corrosion. The conductivity is nil, and the material has, therefore, perfect insulating qualities. Where, however, components are required to have an electric field beneath them Pytram can be readily metallized.

The following data have been published for Pytram PG/AM: Density, 48 lb. per cubic ft.; specific gravity, 0.77; tensile, 3,900 lb./in.^{2}; shear, 2,000-3,000 lb./in.^{2}; bolt-hole tensile, 4,020 lb./in.^{2}; bending test (modulus of rupture), 5,960 lb./in.^{2} The damping properties are high and fairings made of the material would be less likely to flutter than those of metal.

Building with Plastics during the War and After

By George Fejér

An architect visualizes the scope of transparent plastics in the building industry of the future

WE have read or heard only too often the opinion that it is certain that plastics will play an important part in the future development of the building trade. It is very encouraging for the plastic manufacturer, as well as for the architect, to visualize future collaboration. There is little doubt, however, that, except in isolated cases, such collaboration is more an aim than a reality. Naturally, the plastic manufacturer or fabricator who has fulfilled the duties of war-time requirements cannot devote much of his energy to elaborating ideas in regard to post-war reconstruction, and the building trade does not show much enthusiasm for plastics.

If we are really thinking of using plastic components in buildings, properly designed, the planning of the mass production of such elements has to be completed now.

There is a long way to go before a good and practicable design can reach the market in a perfect and sometimes drastically modified form. This period might take months or years, and many an improvement of the design, or manufacturing method, or both, will have to be considered.

This periodical would no doubt give space for any good ideas coming either from the side of the manufacturer or from the designer-architect, in order to create a link between these two, but we must get down to the details—whether it is a new type of hinge or a complete bungalow made of plastics. Ideas which "outline" some "possibility" can fill volumes without bringing us much nearer to the result.

Such a link is essential, not only for the designer to get his plan realized. Undoubtedly there are plastic manufacturers whose plants are doing work now which will have to cease after the war, and who might be interested in switching over to production of some building components when peace comes. They might have a perfect idea of the kind of product they would be able to turn out but cannot anticipate that the product will be a real boon to the post-war building trade unless they have the fullest collaboration of men who come from the building trade and know not only pre-war architecture but visualize the future aims of modern building.

The real aim is not to compete with proved and well-known components by imitating their shape and appearance, because the builder will soon realize that there are new drawbacks in addition to new advantages. It is the entirely new type of exploitation of the properties of the particular material which has to be aimed at. For instance, while a bathroom window can be designed made entirely of plastic elements as a copy of the well-known forms of existing windows, there is no reason why it should not be designed in plastics in an entirely different way, perhaps in a manner similar to motorcar windows.

There might be less difficulty in introducing unorthodox-shaped but standardized and mass-produced units, than substitute copies at prices which are not too attractive to the builder.

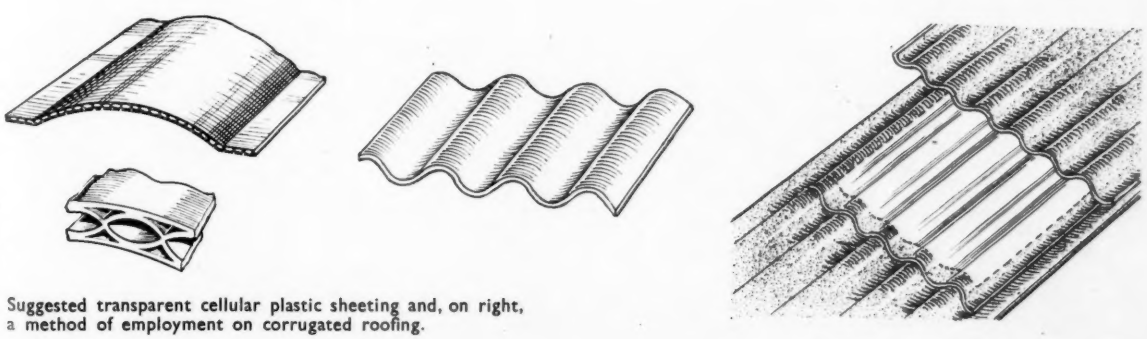
Glass Substitutes

At present there is a great deal of "glazing" being done with plastic materials. It is not appropriate for the writer to deal with the properties and prospects of these products, the number of which runs into several hundreds.

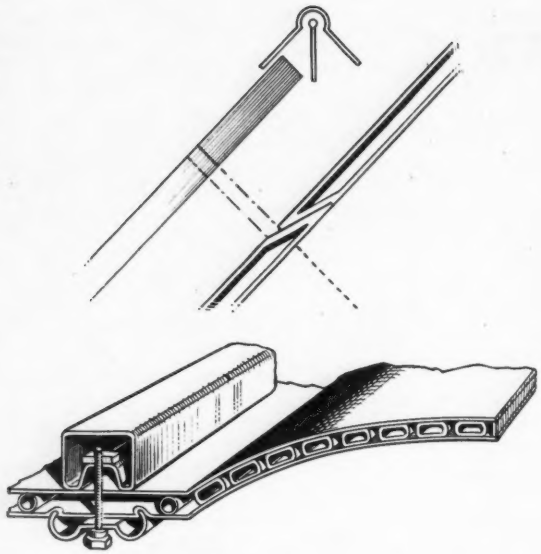
It is certain that plastics will be used in the future as glazing materials to a certain extent, and the present attempts at manufacturing materials for "emergency glazings" have a double effect.

It is an opportunity for the plastic manufacturer to learn something about building requirements and for the builder to get used to the idea that "glazing" is just another building problem, like panelling, for instance, and that besides glass other transparent sheets or boards can be used. These are the favourable points, but, as always happens with new products, there are many builders who have had some unpleasant experience with some cheap glass substitutes and therefore are not much in favour of "plastics." Taking into consideration that so far the majority of the men working in the building trade know very little about plastics, one need not be surprised to know that materials have been used improperly under pressure of emergencies.

The proposition for plastic glazing material described



Suggested transparent cellular plastic sheeting and, on right, a method of employment on corrugated roofing.



(Above) Method of jointing and roof glazing, and (below) suggested type of light glazing bar.

herein is to manufacture semi-rigid, unusually shaped elements which would be by no means a copy of glazing, but an application of thought based on our knowledge of plastics.

The proposition herein described is related to the aim of making transparent elements of the polystyrene and "acrylic" type for peace-time use in building.

The shapes of the sheets are by no means restricted to the two which are illustrated. The principle is that the section is a cellular structure.

Experiments Under Consideration

Experiments with such structures are being carried out now, starting from the simplest "built-up" type of "Isol-umen," a description of which product has been published in the October, 1940, number of this periodical.

A great variety of products of this type are being investigated by the firm, Messrs. Pharaoh Gane and Co., Ltd., but these possibilities, although the patent rights are covered, have not passed into manufacture so far and for the present needs only "Isol-umen," type I, of a cellulose acetate basis, is being manufactured to meet present urgent requirements.

One of the possibilities of the manufacture is to extrude (and pull out) the shapes through a suitable orifice. Obviously the unusual widths (preferably not less than 2 ft.) might cause more concern than the extrusion of a tube or rod, but other advantages of the extrusion method will certainly make worth enough the examination of the difficulties involved. The continuous process and the fact that one single operation is enough, without further "shaping" treatment, suggests that the product could be turned out at a rate similar to competitive non-plastic products. The cellular structure would indicate these possibilities.

The shape might have an overall thickness of, say, $\frac{3}{16}$ in.-$\frac{3}{8}$ in. The channels at both ends, of course, have to be sealed.

Advantages of Plastic Glazing

Translucent, vertical and horizontal surfaces (glazings) can be made whereby many possibilities are opened up where glass could not possibly be used.

The most striking difference may be the weight of such a panel compared with glass, which means that the glazing bars may be cheaper and lighter. With glass, the glazing bars have to be constructed in such a way that the slightest distortion under stress has to be prevented because of the brittleness of the glass; a certain elasticity of such units is anticipated so that light glazing bars* can be used.

The "corrugated" shape is meant to have the same "wavelength" of corrugated iron, so that any part of a structure built of corrugated iron could be replaced by a translucent element, so that neither glazier work nor glazing bars would be necessary.

The curved shape is primarily suitable for extremely light, entirely transparent constructions. The ordinary glazing methods can be used, although it cannot be hoped that such panels will approach glass closely in availability or price; on the other hand, it opens the possibility that large sports halls, aerodromes or other wide-span structures can be covered and provided with a "translucent skin."

The heat insulation of these units will certainly be many times better than that of the glass, according to experience with "Isol-umen," and the water condensation correspondingly reduced.

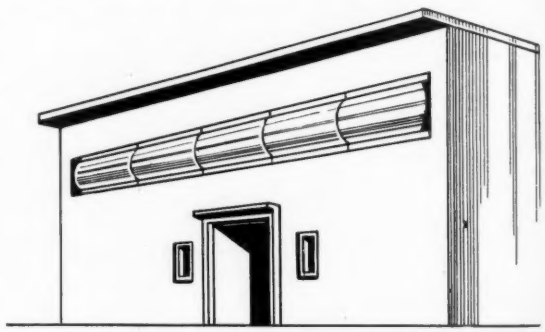
If, however, the channels are not sealed, some "ventilation" effects, though very small, can be maintained through the material.

What it Means to the Architect or Builder

The modern architect often thinks of the utilitarian building as a shell which should, in the first line, give protection against weather and cold. The presence of daylight is of extreme importance. For the erection of a factory or hospital we have a large variety of building materials of different origin and properties, as far as the non-translucent parts of the shell are concerned. For the transparent parts, however, only glass has so far been used.

For the erection of a well-insulated light structure of timber, metal, asbestos, or composite wood units, such as wallboards, the choice of material is nearly unlimited, and glass, with its ever-present characteristics, cannot always compete with the efficiency of such structures. Therefore, glass imposes certain limitations in use. The present proposition is aimed more at the widening of these prospects rather than to compete with glass; the use of such organic elements will scarcely reduce the amount of glass used, but will permit daylight in structures where glass can only be used to a small extent.

* The average weight of a usual glass roof can be put at 5 lb. per sq. ft. The glass used for individual buildings might vary in weight between 2 and 4 lb. per sq. ft. Polystyrene units here described might weigh approximately 6-10 oz. per sq. ft.



A novel design for glazing in a building of the future

Modern packaging enhances the sales value and lengthens the life of the exposed soap tablets.

There are indications that the vast soap industry of the country is becoming acutely aware of plastics. The following notes discuss how they had already entered this field and give some indications and hopes of future applications

Plastics for the Soap Industry

THESE synthetic materials are of considerable present and potential interest to two important sections of the modern soap plant: the packaging department and the works manager's or engineer's office. The packaging department needs thin foils for wrapping soaps; semi-rigid sheets for all kinds of fancy boxes and mouldings for closures, applicators and soap dispensers, not to mention various kinds of special cements and glues for sticking liners on to bottle caps, etc., many of which have a plastic base.

In the works manager's or engineer's office plastics are now being considered in relation to plant efficiency and many new problems are being solved by the aid of thermosetting and thermoplastic resins.

Plastics for packaging materials are of immediate interest to the soap manufacturer, because they offer him a medium for adequately protecting and, at the same time, enhancing the appearance of tablets, bars, etc. Yet there is a wide difference between the wearing properties of the different films on the market, some possessing a relatively high moisture-absorption figure, whilst others are practically non-absorbent; some are remarkable for their sparkling clarity, others for their great elasticity. The range is becoming more extensive and catholic every month and it well repays the manufacturer to make a careful survey of the new materials available from time to time.

The Importance of Packaging

A consideration of modern packaging must deal with the following materials: transparent cellulose film, transparent rubber film, cellulose ester foil, and the new vinyl film.

Generally speaking, there are two varieties of cellulose, that is, regenerated pure cellulose film available to the soap trade. First, the normal type which allows moisture to penetrate its surface and, second, the moisture-proof variety, known familiarly as self-sealing or heat-sealing. This latter type does not need any adhesive for sealing, simply the momentary application of heat. The thickness of both kinds of film for wrapping purposes is usually about 1/1000 in. to 2/1000 in. The sheets can be embossed and printed in one or more colours, and they are themselves available in a wide range of brilliant shades.

Films of Cellulose Derivatives

Where there is a demand for a stronger and more rigid packaging material, then celluloid or cellulose acetate is worthy of consideration, although, of course, it must be remembered that both materials have to be regarded as luxury lines and a greater price margin must be allowed. The sheets, which usually vary in thickness from 3/1000 in. upwards, according to the degree of rigidity desired for the pack, can be cut easily with a hand guillotine, folded and generally worked without difficulty. A simple benzene-acetone solvent, 200 c.c. benzene to 1 gallon of acetone, enables sheets to be cemented together to make very strong, quick-drying joints. Great toughness, water resistance and ease of fabrication and cementing, together with brilliant clarity, are factors which render both the nitrate and acetate of such value as packaging materials. The inflammability of the nitrate is, of course, the main disadvantage of this ester, but during recent years the fire hazard has been considerably reduced.

Another foil material worthy of comment is cellulose-acetate butyrate, which has a lower specific gravity than the straight acetate, 1.21 compared with 1.31. Outstanding properties of the acetate butyrate are excellent weather resistance and low water absorption. On continuous immersion cellulose-acetate butyrate absorbs about one-half as much water as the normal acetate. Although somewhat more expensive than the nitrate or straight acetate, the acetate butyrate is well worth consideration for specialized packaging applications.

Rubber Modified and Rubber-like Films

A comparatively new entry into the soap-packaging field is transparent rubber wrapping material, the best known being a type of rubber hydrochloride. This differs from the cellulose film in that it is stronger, more

elastic and, naturally, extremely water-resistant. It is completely odourless and quite unaffected by mineral and vegetable oils, waxes, etc., also indifferent to weak acids, alkalis, mould and insects. As many as five different thicknesses are available for the packaging industry, but the two most popular are 1/1000 in. and 2/1000 in. All thicknesses may be laminated, printed and sealed with the greatest of ease. Coloured sheets, tapes and seals are available. Effective sealing temperature is 115 degrees C., which compares very favourably with approximately 130 degrees C. for cellulose foil. The sealing temperature of the rubber film can be reduced by 35 degrees C. if a solvent, such as toluol, is used in conjunction with heat, and the strength of the seal may be adjusted to suit particular packaging needs. There is no dimensional change in the humidity range of 15 per cent. to 90 per cent. and it does not, therefore, wrinkle or crease in the same way as cellulose. Elasticity is claimed by the manufacturers to be twice that of cellulose film.

Of comparatively recent interest is the vinyl-resin calendered film 2 mils to 5 mils in thickness. This new and important foil is likely to make considerable headway in the wrapping of soap and beauty preparations. It is tasteless, odourless, non-toxic and exceptionally strong, tough, and does not curl, blush or get sticky when in contact with moist air. It is also non-inflammable, resistant to moisture, oil, alcohol and a great number of other chemicals. In addition, it can be printed on in multiple colours with perfect register, and, most important from the sales angle, the finished pack does not warp or shrink on ageing.

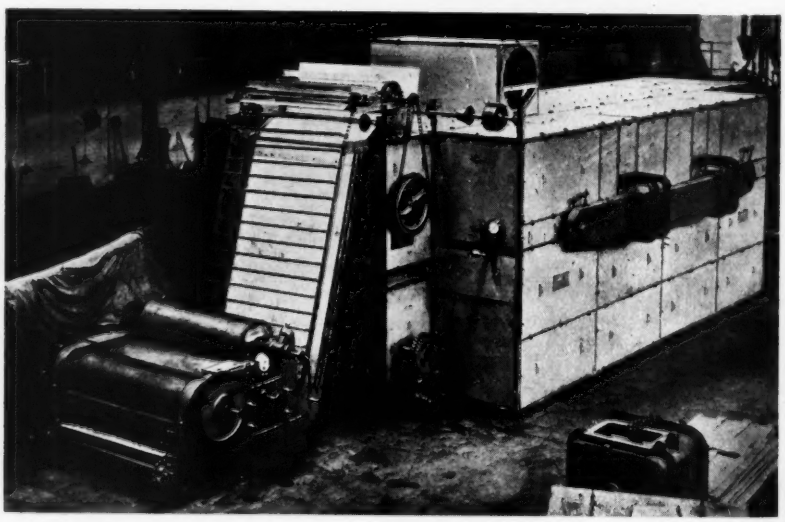
Applications in Soap Manufacture

On the engineering side of the industry plastics offer their most interesting applications. In the field of metal coatings, for instance, there is a great future for both thermosetting and thermoplastic resins. They are often able to give complete immunity to metal from chemical attack and thus allow what might seem to be derelict plant to be pressed into service. At a time when stainless steel, aluminium and nickel alloys are becoming increasingly difficult to procure, the advantages of being able to use old tanks, etc., with the assurance of reasonably high efficiency is surely a great attraction. Of great interest also is the use of plastics for pump valves, roller bearings on flake and chip mills, various kinds of gears, friction drives. Here, again, laminated plastics, specific gravity approximately 1.3 to 1.4, which have a minimum tensile strength of 7,500 lb. per sq. in. and a Young's Modulus of 4,000,000 lb. per sq. in., enable, in approved cases, economies in power consumption to be effected alongside a reduction in machine breakdowns. Potential applications of plastics on the works side include the use of special laminated panels for the sides of soap-drying machines and the employment of resin-impregnated wood for making soap frames.

To describe in detail the dozens of applications of plastics in the soap industry would require far too much space, but it is sufficient for the present purpose to state that the works engineer and the chemist will find these materials of increasing practical value. Already in Germany quite extensive use is made of tanks built of asbestos reinforced with special phenolic resin, which is able to withstand caustic soda and potash, usually considered troublesome chemicals from the phenolic-resin standpoint. Even dilute alkalis attack the ordinary phenolic resins. It is not suggested, of course, that such tanks should hold strong soda solutions.

This plastic material has a compression strength of about 5.2 tons per sq. in., bending strength of about 2.8 tons per sq. in. and is only one-fifth the weight of steel. In addition, it withstands sudden temperature changes and for normal working is able to stand up to 140 degrees C.

The employment of plastics for coating metal surfaces to replace glass linings or the use of special non-staining alloys is attracting a great deal of attention in a number of industries, particularly the fermentation industries, and there is no reason why they should not prove of service in the soap and allied trades. The plastic coatings can, if desired, give a vitrified-like surface easily sterilized with steam or hot water, and are immune to attack by moisture, fatty acids, weak alkalis, etc., and have an unsurpassed ability to withstand mechanical shock and rapid temperature changes. In one well-known method of treating metal surfaces with a special phenolic varnish the resin, in solvent solution, is sprayed on to the properly cleaned metal surface and then baked under carefully controlled conditions to complete polymerization. The whole operation is performed in situ and the baking or heating is done in a lagged enclosure rigged up for the purpose; hot air is used as the heating medium. Apart from the phenolic coating mentioned above, some of the thermoplastic materials are of considerable interest, particularly poly-



The modern soap-drying plant is suggested as a possible field for plastics.

vinyl chloride, which can be used in sheet form for lining tanks and other vessels. This resin is highly resistant to chemical attack and, unlike rubber, is unaffected by oils. It is also tasteless, odourless and exceedingly tough and wear resistant. The use of reinforced phenolic resin, that is a cold-cured phenol-formaldehyde resin strengthened with blue asbestos, for building up pieces of chemical plant, has been mentioned. This material is well recommended for many types of tanks and reservoirs likely to be needed by the soap manufacturer. A grade is available which is able to withstand the attack of alkalis and maximum heat is 130-140 degrees C. They should be especially useful for the storage of fatty acids.

Cylindrical tanks up to 10 ft. in diameter by 10 ft. deep and of a wall thickness of ¾ in. have been moulded in one piece of this cold-cured phenolic resin. This tank needs no exterior steel bands or wooden holding structures, such as are required for larger vessels. Small units, such as pumps, agitators, fans, filter-press plates, steam injectors, low-temperature stills, buckets, etc., have also been moulded of this resin. In Germany such items as density meters, ball valves, large pipes, pistons, plugs for cocks, etc., have been constructed; that is, moulded or machined from blocks of a new cast resin.

In the soap industry more extensive use could undoubtedly be made of plastics, although, of course, in the case of pumps care would be necessary to ensure that the resin employed had good resistance to alkali attack. Plastic bearings for flake and chip rollers offer signal advantages already observed in other industries over a number of years. Plastic bearings have a low coefficient of friction and thus greatly reduce power requirements and working costs. The points of chief interest to the works engineer in the soap plant are that synthetic bearings are able to withstand the severest punishment under the most destructive conditions of overload, neglect and lack of lubrication, which, of course, are particularly severe on even the best metal bearings. The plastic bearings are also able to withstand sudden changes in temperature, most important to the engineer, and possess the resiliency and strength to resist crush loads.

A suggestion which may prove of interest to manufacturers is the use of laminated sheets for the sides of soap-drying machines where their excellent insulating property coupled with light weight and resistance to wear would be undoubted practical advantages. Use could be made of high insulating composite sheets consisting of two sheets of laminated phenol-formaldehyde panels for the outer ones and the inner one being of aluminium foil. Transfer of heat through the phenolic resin sheet and through air is very small, but the greatest insulating effect is due to the polished aluminium, which reflects heat waves very effectively.

The suggestion mentioned earlier, namely, the use of impregnated wood for soap frames, is deserving of consideration. The resin impregnated wood possesses unusually high mechanical properties and an exceedingly low moisture absorption, less than 1 per cent. in 24 hours. Its specific gravity is only 1.40, and tensile strength considerable, 16 tons per sq. in. for some varieties. As the normal or standard type of soap frame is made of blue annealed steel, ends made of white pine and lined with sheet iron and bottoms of white pine, cypress and maple, altogether a rather cumbersome and expensive piece of equipment, it will be obvious that phenol resin impregnated wood offers great practical advantages.

CAST RESINS IN INDUSTRY

Phenol-formaldehyde moulding powders began their useful life in the electrical trade, but the cast phenolic resin, until very recently, did not seem capable of forcing itself out of the rut—albeit a beautiful rut—it first entered, namely, the fancy goods trade which deals more especially with buttons, buckles, dress-ornaments, lamp-stands, and so on. Industry, as a whole, regarded it as " too good to be true," and the designation of it by a famous manufacturer as " the gem of plastics " did not help to disperse this industrial misconception.

Yet it is a very strong material, surpassing indeed the strength of concrete under compression and approaching that of cast iron. Moreover, because of its manner of production, that is, water is finely dispersed through it, internal stress is very uniform and low with the result that the cured resin is not brittle and can easily be machined.

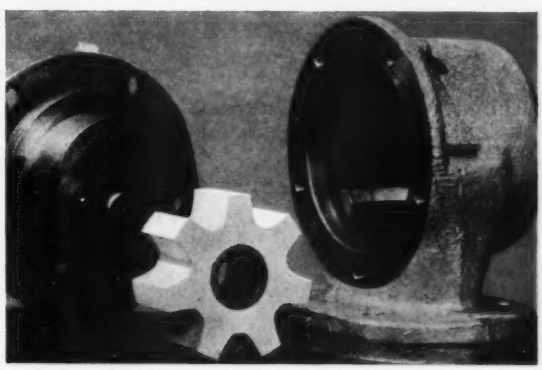
In recent years the manufacturers have made endeavours to interest industrialists in resin castings, because of the simple methods of moulding combined with a resultant strong moulded object with the added advantages if desired of transparency and acid resistance.

The first news of such use appeared from the chemical industries, where the most important desideratum was acid resistance accompanied by strength, for the production of acid piping and acid pumps. Here, in the chemical industry, the strength was not of paramount importance, for silica pipes and silicon-iron vessels are normally used and are generally protected by exterior staging.

In Great Britain, the largest industrial castings made were, so to speak, industrial, yet they also possessed the advantage of being inherently beautiful. We refer to the hundreds of pale cream lavatory seats that were installed just before the war broke out in the newest passenger liner.

More recently a novel use of phenol-formaldehyde resin casting has been made for Rolls Royce, Ltd., by a well-known London concern. It is an exact replica of a water-pump in transparent material machined from the solid block. It was ordered by Rolls Royce, Ltd., for purely experimental purposes, " to see what happened inside." We hope to publish a photograph of this interesting object in our next issue.

We may complete this short survey with a note of an interesting American development. The Schirmer-Dornbirer Pump Co., of Cleveland, Ohio, have produced a petroleum pump in which the gear is of Catalin, the well-known cast phenolic. This is an important application, for the material was chosen because of its basically desirable qualities, acid and oil resistance, strength and silence in operation.



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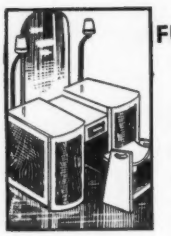
World's Industry

ELECTRICAL

High - frequency insulators of low thermal expansivity based on thermoplastic resins are discussed in a past communication from the laboratories of Julius Karl Görler, transformer manufacturers. The author, E. Scholz, presents in tabular form coefficients of thermal expansivity (linear) for the following range of materials:—Trolit W (130×10^{-6}), Trolitul (102×10^{-6}), Trolitul Luv M100 (101×10^{-6}), Trolitul Luv M125 (86×10^{-6}), Trolitul Luv M150 (70×10^{-6}), Amenit A (50×10^{-6}), Amenit B (55×10^{-6}), Amenit C (36×10^{-6}), Amenit A100 (37×10^{-6}), Amenit B100 (83×10^{-6}), Amenit C100 (35×10^{-6}). These figures are of importance, particularly for the permanence of metal fixtures moulded into the resins, such metal parts tending to heat up under the influence of high-frequency currents. Unfortunately, even for temperatures far below the softening point, the thermal expansivity curves are rarely truly reversible; shrinkage occurs to a greater and lesser degree as shown in the following data for resins heated once only to 50 degrees C.:—Trolitul, 0.21 per cent.; Trolitul Luv M100, 0.09 per cent.; Amenit A, 0.014 per cent.; Amenit C, 0.012 per cent.; Amenit A100, 0.009 per cent.; Amenit C100, 0.006 per cent. (See also expansivity figures previously given.) Special methods have been evolved to give Amenits with thermal expansivities identical with those of certain metals over certain temperature ranges. As opposed to ceramic insulators, appropriate resins may be fabricated into required forms in one instead of four or five operations, and assembled in as little as a quarter the time of the former. **Technical and economic facilities governing the exploitation of plastics in electrical engineering** are considered in a past issue of "Chemische Apparatur." Discussion is devoted chiefly to the position in the U.S.A., where, it is pointed out, the phenolics command widest popularity. Where the resistance to arcing of these alone is insufficient, applied coatings of alkyd resins are employed. Urea resins are somewhat too expensive adequately to compete with the phenolics in U.S.A. in spite of certain advantages they possess; a similar state of affairs holds good for aniline resins. Polymerizates do not appear at present likely to threaten the popularity of either phenolics or alkyd resins, in spite of their growing field of utilization in many branches of industry.



FURNITURE

Relief - globes specially developed for use in schools for the blind, but possessing obvious values in other directions, are described in a past issue of "Die deutsche Sonderschule." The disadvantages of the cumbersome and easily damaged plaster globe are noted, and the expense of the cold-pressed metal job is condemned. The resin relief-globe, however, besides being light and strong and capable of being coloured to suit any requirements, presents little more than ordinary moulding difficulties. **Slide rules in plastics** are referred to in a recent issue of the "Frankfurte Zeitung." As dimensional stability and constant ease of manufacture are important, a polyvinyl resin was selected. The resistance of the material to change of form by water absorption or by temperature changes (during handling, for example) is notably high, whilst dividing may be carried out directly upon the dead white surface of the mass of which the complete rule and slide are constructed. Finally, the mechanical strength of polyvinyl resins is very high, and thus distinctly suitable for this particular application.

CHEMICAL

Metal containers are coated internally with Igelit by first cleaning and roughening the metal surface by sandblasting, then applying two or three coats of a special adhesive (the composition of which is not stated), the solvent residues from which are drawn off by gentle external heating after the coatings have dried. Igelit foil, 0.2-0.5 mm. thick, is then caused to adhere by warming the container uniformly to a temperature of 130 degrees C. (i.e., the softening point of the resin). Air bubbles and inclusions are eliminated by the application of direct pressure, or by gentle rubbing. Edges and rivet heads are covered by overlapping with strip Igelit foil 50 mm. wide. The continuity of the coating is determined by means of an induction coil, the voltage of which is so regulated as to cause breakdown only at weak points. **Polyvinyl chloride coatings** may be similarly applied, the adhesive used in this case being PC 10, three successive coatings of which are applied, the first being allowed thoroughly to dry before the next is brought into contact with it for 12 hours at room temperature. The film (0.5 mm. thick) is coated with PC 20, which is allowed to dry and is then applied as before to the metal surface pre-warmed to 130 degrees C. Wood, concrete and brickwork may also be similarly rendered impervious by suitable modification of technique.

GENERAL ENGINEERING

Modified lubricant requirements of plastic bearings are briefly noted in a past issue of "V D I Zeitschrift." The low heat conductivity of plastics makes it essential to use adequate supplies of lubricant in order that heat may be dissipated by direct fluid transfer. To ensure flooding, ring oilers and analogous types are advocated, and because of the higher operating temperature of the oil, this should initially be of adequate viscosity and should be of a type maintaining a suitable viscosity under running conditions. Greases are often to be preferred to oils, but carry with them the danger of causing swelling of the plastic, a point which must be guarded against by providing generous clearances, and by promoting swelling prior to assembly. It is noted that Lignostone and Lignofol exhibit this property, which tends to restrict the use of plastic bearings to those cases where particularly fine clearances are not demanded. Unlike metals, plastics do not provoke chemical changes (e.g., gumming) in oils. **Armoured copper tubes** marketed as "Cuprema" tubes are described in a past issue of "V D I Zeitschrift." The copper tube itself, of wall thickness 0.2-0.3 mm., is armoured with resin-impregnated paper 2.3-3.7 mm. thick, the process being carried out in specially designed heated rollers which wind the paper around the tube. The effect of pre-compression on the tube is to raise bursting pressure to that of a thick-walled copper tube, whilst impact and external pressure strength are actually raised by the reinforcing effect of the metal on the strong plastic winding. Copper-lined steel or cast-

...stmploys Plastics

iron sleeves are used for jointing, whilst shaped presses must take the place of bends as the covered tube itself cannot be bent. In practice tubes constructed on this principle have been used up to pressures of 120 atm. **Sewing machines** embodying driving shaft, working arm, baseplate, etc., in the form of moulded plastics have been produced for experimental purposes and operated for more than 100 hrs., giving eminently satisfactory results. The machine itself was of a much more manageable weight than the conventional type embodying cast-iron units. The main castings in the machine were in light alloys. **Welds in thermoplastics** are stated to have an optimum factor of safety of 0.6.

TEXTILES

World production of rayon and cellulose yarn has considerably increased during the past year. Rayon production in 1940 was 1,150 million lb. compared with 1,145 million lb. in 1939. World cellulose yarn production rose from 1,080 million lb. in 1939 to 1,350 million lb. in 1940. The U.S.A. produced 390 million lb. of rayon yarn, equivalent to 34 per cent. of world production. Cellulose yarn production in the U.S.A. was 81 million lb. in 1940 and 51 million lb. in 1939. **Leather substitute,** under the name of "Fagelan," is said to be meeting with success in Germany. It consists of a textile base with synthetic internal and external waterproof coatings. The material has a leather-like appearance and possesses a pressed-in grain. It is used for uppers. For soles another type of so-called artificial leather, "Fabenit," is said to be satisfactory. Soles are also made of "Nifarin." We forbear to comment upon the euphony of these trade names. **Felt-like mass** possessing in some degree the properties of natural cork and suggested as a substitute for the latter, is manufactured by the moulding under heat and pressure of clean potato peels. Process of manufacture and use are described in D.R.P. 697,435. **Whale-skin** may shortly be worked up into what appears to be a species of synthetic fibre, according to recent references in the Japanese technical Press. From a single whale (size unspecified) it is hinted that sufficient yarn might be obtained to provide cloth for 60 suits!

BUILDING

Intrinsic advantages of plastic tiles as opposed to ceramic tiles, slates and sheet metal were noted in a recent technical article by Pabst. Synthetic resins are more resistant to chemical change than the commonly used metals; even in urban or marine atmospheres they are, in addition, far lighter, hence, supporting structures in buildings can be made correspondingly less weighty, thus resulting in a saving in timbering expenses and in the provision of opportunity for the better use of limited space. As opposed to wooden shingles, those in plastics are entirely non-inflammable and can neither absorb large quantities of water or give lodgement to insect or fungoid pests. The suggested use is not new, nor of German origin; Mipolam is put forward as a suitable plastic.

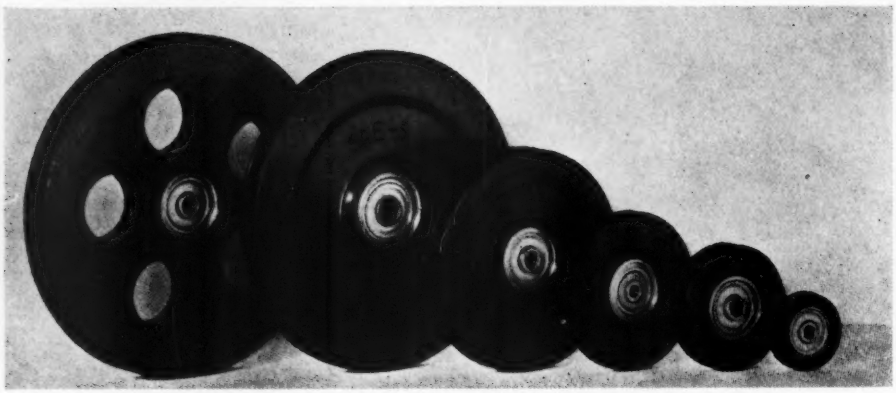
MISCELLANEOUS

Mechanical and other properties of Polyamid 6351 (Vdt), an amino-resin developed a few years ago in Germany, are given in a past issue of "Kunststoff Technik und Kunststoff Anwendung." It is pointed out that the material is not suitable for normal moulding, but only for injection moulding, the optimum temperature being 230-240 degrees C. to prevent too rapid chilling of the material; the die temperature should not fall below 230 degrees C. Sprues should be as narrow as possible (about 1 mm. dia.) and particular attention should be paid to the safety of the die-locking mechanism. The material has an S.G. of 1.13, a tensile strength of about 4.5 tons/sq. in., and a notch impact strength of 11 cmkg./sq. cm. The water absorption characteristics of the resin resemble those of casein; it is unaffected by benzene and light petroleum fractions and against many organic solvents. Concentrated mineral acids cause it to decompose. The resin is more resistant to the effects of low temperatures than celluloid. In the form of a solution in 80 per cent. formic acid, it may be employed as an adhesive for parts in Polyamid 6351.

General status of the plastics industry in Italy were revealed in the 1939 Milan Exhibition. Società Montecaline exhibited phenolics under the names "Fluosite," "Reflite," "Tessilite" and "Fenoplast G," together with a new acid-resistant resin for chemical apparatus ("Titan"). An aminoplastic, "Gabrite," and "Keratol" and "Rexol" were also shown, as well as "Tessiflex" and an adhesive resin "Xilocolla." A special point was made of mouldings for railway-carriage fitting. The Società Italiana Resina showed amino-resins, "Sibitle," with a cellulose filler, and "Scarabeo," with woodflour filler, together with urea resins in various forms. S.A. Isola showed units for electrical apparatus in "Dellite," and "Radiolit," gears in "Canevasit," and bearings in "Isotex." Fabrica Italiana Prodotti Speciali Carlo Pasquetti exhibited an injection-moulding powder "Cellose," "Flexil," for cable and wire sheathing, and "Metalplast," a heat-resistant resin suitable for moulding or injection moulding. A number of concerns exhibited ranges of fabricated articles of more or less familiar types. Incidentally, some attention is drawn by the compiler of this review to the alarming multiplicity of trade names, a feature which, in the metal world, has also caused some dismay amongst users of aluminium-base alloys. **Transport by land, sea or air demands the wider use of plastics,** according to a past issue of "Materie Plastiche." The instances cited refer to Italian developments, and it is noted that Italy tends to lag behind world development, more particularly in average consumption for automobiles.

AIRCRAFT

Zeppelin under construction just before outbreak of war promised to provide useful outlet for world exploitation of plastics, notably Mipolam. Hydrogen filling was contemplated and the non-flam qualities of the plastic, plus the fact that it does not smoulder after removal of flame were particularly stressed. Availability in a wide variety of forms and in colours from transparent to black, together with high mechanical strength and low specific gravity were further points emphasized, and the shortcomings of magnesium were contrasted unfavourably with those of the resin. Interior fittings in passenger's quarters and equipment in engine-rooms were tabulated as further fields for the utilization of Mipolam or an equivalent plastic.



Big Wheels and Little Ones

OUR remarks on the possible introduction of plastics into baby carriage manufacture has aroused some interest both among carriage manufacturers and certain sections of the plastics industry. There is at least common agreement on one point—the perambulator manufacturing industry is a big and an important one.

It would appear, on the whole, that those manufacturers who know little or nothing about plastics and who are now confronted with the acute metal shortage, labour under the delusion that plastics can be made to replace all metal parts in the baby carriage structure.

The plastics manufacturers are by now fully aware of the shortcomings as well as the advantages of their own material. They are also aware of the dangers of entering precipitately an industry in which designs and sizes are noteworthy by their prolificness, a condition which is bound to restrict production by what are virtually, at least in the moulding side of the industry, mass-production methods. There is also prevalent a natural cautiousness in dealing with any industry which knows not plastics, and which may revert to metal on a price basis when metals are available, irrespective of superior or more appropriate materials. This cautiousness is, we hope, misplaced. The baby carriage is not generally a cheap structure but a carefully made object selling at anything between £7 and £30. Where plastics are better or more æsthetically satisfying there will be little question of cost.

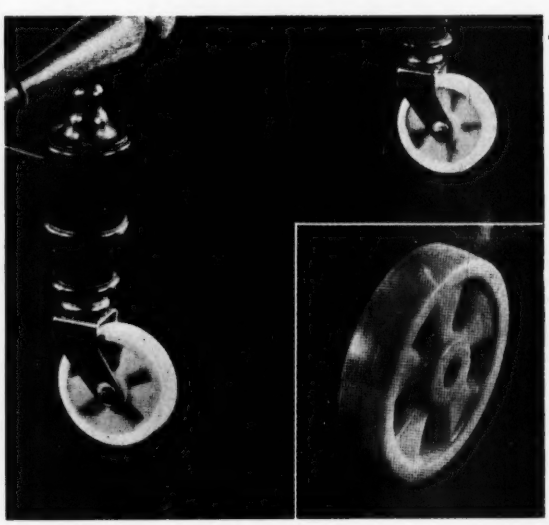
From the plastics angle the wheel is an interesting point of attack. There is one significant change in the design of the baby carriage that is extremely satisfying. The very large wheels of the old type, often 2 ft. in diameter, are fast disappearing and the sensible low-slung carriage with wheels 6 ins. to 8 ins. in diameter is almost universal.

Is the plastic wheel possible and of what should it be made? Economically speaking, there seems no doubt that the number required makes it a very attractive proposition. We do not possess any figures of the number of carriages made in this country, but we can get a rough idea from the number of births—about 750,000 per annum. If we put the number of carriages required at 1 to 4 of the births (this is merely a convenient figure and unrelated to known facts), the number of wheels required is still 750,000. If there were standardization to one or two sizes, between 6 ins. and 8 ins. diameter, this quantity or even a small fraction of it would satisfy the plastics industry very well.

From the greatest strength and wear point of view, and if standardization were completely lacking, the cutting of wheels from impregnated laminated fabric has its attractions. The manufacture would be very akin to the production of pulleys now being widely made from this material, the sunken rim being filled, of course, with a solid tyre.

From the moulding point of view the job is still more attractive. Made with a fabric-filled powder, the wheel moulded solid or with thick spokes would be sufficiently strong and as colourful as required. It has been suggested that acetate, "acrylic" or cast phenolic resin wheels would be even more appealing. So they would, and injection moulding of the first two types sounds attractive. There would probably have to be some insurance against "the slings and arrows of outrageous fortune."

How attractive a moulded urea resin wheel can be is seen in a different type of structure for which there is a huge field untouched in this country. Chair wheels, while much smaller and not subjected to the severe jolts of street-riding, are far from free of rough usage, so that we shall follow their impact on this industry with interest. The wheels shown in the photograph are moulded of Plaskon, the well-known American urea-formaldehyde resin.



Inquiries and Answers

(In Which is Included General Correspondence)

IMPORTANT NOTICE: If inquirers wish to receive replies by post, a stamped and addressed envelope must be included in their letter. It is understood that the submission of a problem to the Editor permits its publication in this journal.

Plastics for Model-making

The two samples enclosed are made of a material consisting mainly of woodflour and a small percentage of either celluloid or cellulose acetate scrap. The

moulding process is most simple and these articles have been made in a letter press.

One of your correspondents (Plastics for Model-making—February, 1941) is asking for a "grainless reconstructed wood." Do you think my material and method of moulding would be of interest to some firm?

Darwen. O. SYLVESTER.

[EDITOR'S NOTE.—We think it is quite possible that the inquirer in our February issue alluded to some such material. We presume that rods made from it can readily be worked on a lathe. The examples shown appear to be umbrella handles.]

High Temperature Cements

On page 82 of the April, 1941, edition of your admirable journal, "Plastics," you published the letter of one J.S.T. inquiring about a cement which would withstand temperatures of 200 to 250 degrees C.

We have been doing some research on organic resins for this purpose, and have one on hand which was exposed to 235 degrees C. for two months without much apparent damage. We regret that the strength at this temperature is nothing to view with pride. However, if J.S.T. would tell us more about the specific application he has in mind, we would be willing to test our material for the purpose. PLAX CORPORATION.

Hartford, Conn.

[EDITOR'S NOTE.—The original inquirer asked for the material with a view to use in low-temperature furnace work. We have asked him to get into direct touch with you.]

Powders for Button Manufacture

We have customers in Australia who are anxious to import a powder suitable for the manufacture of buttons, and if you can suggest the names and addresses of any likely suppliers we shall be extremely grateful.

W. A. SPARROW AND CO., LTD.

Bishop's Stortford.

[EDITOR'S NOTE.—Actually, we should have liked fuller information as there are several types of powders, depending on the type of button required, also the moulding process available. We suggest that you obtain this information from your Australian customers.

In the meantime, you may wish to know that there are the usual "phenolic" moulding powders which can be obtained from Bakelite, Ltd., Birkby's, Ltd., I.C.I. (Plastics), Ltd., etc. Urea moulding powders can be obtained from British Industrial Plastics, Ltd., and I.C.I. (Plastics), Ltd. Both the foregoing types are moulded in high-pressure moulds. Other types of powders now being used for button manufacture are the thermoplastic type which can be obtained either in transparent or opaque form and are usually moulded by injection moulding. Of these cellulose acetate is made by BX Plastics, Ltd., and Erinoid, Ltd., polystyrene British Resin Products, Ltd., and methyl methacrylate powders I.C.I. (Plastics), Ltd.

We presume the inquirer knows of the use of casein and cast resins for button manufacture and is not concerned with them.]

Properties of Vinylidene Chloride

We are anxious to obtain as much information as possible concerning the physical properties of vinylidene chloride materials, and shall be much obliged if you can put us in touch with any firms in this country producing this type of material.

If you can also let us have brief details of the preparation of vinylidene chloride we shall be very grateful.

Glos. ROTOL AIRSCREWS, LTD.

[EDITOR'S NOTE.—So far as we know this material is made in America only, by the Dow Chemical Co., Midland, Michigan. If there is any importation into this country information may be got from Monsanto Chemicals, Ltd.

Polyvinylidene chloride is made from vinylidene chloride, a colourless liquid boiling at 31.7 degrees C. Its formula is $H_2C=CCl_2$ or unsymmetrical dichlorethylene.

A wide range of polymers is, of course, possible, those on the market ranging from a flexible material with a softening point of about 70 degrees C. to a hard, tough thermoplastic solid with a softening point of over 180 degrees C. They all exhibit certain crystallinity of structure, the harder the material the greater the crystallinity. The crystals are rather in the nature of a so-called fibrous crystal which, when the resin is normally made, are arranged in heterogeneous manner and in this shows a comparatively low tensile strength—about 8,000 lb. per sq. in. The crystals may be oriented into ordinary linear pattern when the tensile strength may be increased to 60,000 lb. per sq. in., accompanied by greater flexibility. It is stated that in a series of tests the resin withstood a quarter of a million bendings through an angle of 180 degrees over a ¼-in. mandrel without breaking.

Physical and Mechanical Properties

Modulus of elasticity in tension, lb. per sq. in. $\times 10^5$	0.4—2.4
Specific gravity	1.6—1.7
Tendency to Cold flow	Slight
Dielectric strength, volt per mil $\frac{1}{8}$ in. thick	500—2500
Water absorption after 24 hours	0.0%

The polyvinylidene chloride resins are characterized by their great chemical resistance towards acids and alkalis in almost any concentration at ordinary temperature.

At present the resins are being used for a wide range of purposes, e.g., woven fabrics for the covering of car and chair seats, fishing lines, cords, as a bonding agent for abrasive wheels. The new resins are also suitable for compression and injection moulding.

Perhaps you know that a very similar material, in appearance and properties, is Polythene, manufactured by I.C.I. (Plastics), Ltd.

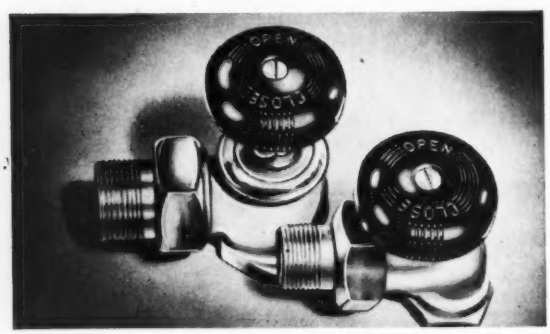
If you would care to give us some indication of the purpose for which you require these materials we may be able to give some further information.]

Plastic Valve Regulator Wheels

We are enclosing an advertisement from the Plastics Department of General Electric Co., of Pittsfield, Mass., U.S.A., and would be glad if you could bring us in touch with the makers of similar valve handles in this country.

We are makers of the Arkon-Telco Seat-in-Sleeve Valve and would like to improve the design of our hand-wheels.

It may be that we could rely on existing designs of



hand-wheels in this country made from plastics, because we believe that the relatively small number of handles required would not justify the expense of making special mouldings.

WALKER, CROSWELLER AND CO., LTD.
Cheltenham.

[EDITOR'S NOTE.—We feel sure that there are similar wheels made in this country, and General Electric Co., Ltd., should obviously be approached, but you should also try Birkby's, Ltd., who make many fittings of this type by normal powder moulding. In addition, we believe Catalin, Ltd., has made cast resin valve wheels or similar objects.]

Plastics for Corset Steels

Do you happen to know if any firm in the industry has investigated the possibility of any of the plastics taking the place of steel as supports in women's corsets?

We are one of the largest distributors of corsets in the country and are keenly interested in the development of possible substitutes for steel in these garments, not only because of the need for conserving steel, but also because a plastic might prove to be a more pleasing and more suitable material.

If you have heard of any developments in this direction, we would feel most grateful to be put in touch with the firm concerned. AMBROSE WILSON, LTD.
London, S.W.1.

[EDITOR'S NOTE.—This problem has already been put to us before and our reply did not give much hope. No plastic has the springiness, resilience and strength of steel, although good substitutes might be made from special "vinyl" resins. These plastics and others, however, are not readily available in war-time. We believe vulcanized fibre has been tested and, of course, cellulose acetate in thickish strips should give fairly good results. On the whole some compromise might be arrived at using a strong steel wire, say, $\frac{1}{16}$-in. diameter, extruded through an acetate strip of the requisite width, say, $\frac{1}{4}$ in. Thus stiffness and strength of the plastic would be improved by the use of a small quantity of steel. Laminated impregnated sheet has also been suggested for this purpose.

Moulded Accumulator Cases

Can you tell us if anyone makes a plastic which might serve as a substitute for metal in cases such as are indicated in our enclosed leaflets? The material must be strong and tough and proof against the action of strong caustic potash. We are told that no such material exists, but even if this is a fact there must be people who are working on the problem. X.Y.Z.

[EDITOR'S NOTE.—While the moulding is a comparatively simple job the difficulty lies in the strong alkali used. All the ordinary thermosetting resins, both phenol-formaldehyde and urea-formaldehyde, decompose under the continual effect of very strong alkalis.

On the other hand, some of the thermo-plastic resins stand up to strong alkalis very well indeed. For example, the co-polymerized vinyl chloride-vinyl acetate resins, polystyrene and methyl methacrylate resins are extremely resistant. The cost, however, of these compounds is much greater than the ordinary thermosetting resins and they are generally less strong in some respects. The vinyl type can be obtained in both rubbery consistency to a hard, tough material. There is also the aniline-formaldehyde resin which is also considerably resistant to strong alkali.

On examination it might be found that a suitable case can be made from one of the thermosetting resins lined on the inside, for contact with the alkali, with a film of one of the foregoing thermoplastic resins.

The following is a list of concerns to which you should apply for further information on the subject:—Thermosetting resins: Bakelite, Ltd. (phenolic); Birkbys, Ltd. (phenolic); British Industrial Plastics, Ltd. (urea); I.C.I. (Plastics), Ltd. (phenolic and urea), etc. Polyvinyl resins: BX Plastics, Ltd.; I.C.I. (Plastics), Ltd. Polystyrene resins: British Resin Products, Ltd. Aniline-formaldehyde resins: Micanite and Insulators Co., Ltd. Methacrylate resin: I.C.I. (Plastics), Ltd.]

The Auto-engraver

In our August, 1940, issue we described this new motor-driven engraver which reproduces letters, names, designs, signatures, etc., traced from original drawings. Several British concerns asked the address of the makers but, unfortunately, we did not have it then. We have now much pleasure in informing inquirers that the name and address is: Auto Engraver Co., 366, Fifth Avenue, New York, U.S.A.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

ROTOTHERM DIAL THERMOMETER (Model 41).—This recent issue of the wide series of temperature indicators made by British Rototherm, Ltd., is a special design of the portable type, and is suggested for use during the heating of plastic materials of many kinds. It consists of a stainless iron stem 2 ft. 6 ins. long with an indicating dial at the top, and above this a heat-insulated handle. The thermometer is grasped by the handle, plunged into the hot compound and the temperature is easily read off. As with other thermometers of this make, temperature indication depends upon the expansion or contraction of a bi-metal strip in the form of a coil. The new thermometer is especially useful for the melting and solution of bitumens, synthetic waxes and natural resins, as well as those made by synthesis.

BALAX, BALING WIRE SUBSTITUTE.—Manufacturers concerned with the use of baling wire for large packages will be interested in a new development of British Ropes, Ltd., the production of a fibre substitute called Balax. While it was invented in order to conserve supplies of steel, this concern state that its use effects a saving of over 20 per cent. in baling costs. The production of Balax is now subject to the Hemp Control Section of the Ministry of Supply.

DAMASOL.—It is a significant fact that while synthetic resins were introduced into the world some 25 to 30 years ago, in order to provide use with materials that were purer than the natural resins and not so variant in quality, the modern scientist has also tried to improve the natural variety in order to make it more acceptable to industry. The most recent recruit of the modified form is Damasol, a new purified damar made by Margros Chemicals, Ltd., and sold by its agents, Scott, Bader and Co., Ltd. Damar has long been one of the best general-purpose resins for use in conjunction with nitrocellulose lacquers. Since the raw materials coming from Batavia, Penang, Borneo and Singapore are highly variable soft resins with difficult solubility characteristics, the purification has frequently entailed much troublesome and tedious work. The modern highly refined rewaxed hard damar known as Damasol is a great advance on the old varieties.

RESERVED SCHEDULE.—Several changes in the Schedule of Reserved occupations are announced by the Ministry of Labour. Stock-keepers in "unprotected" establishments hitherto reserved to 35 are de-reserved immediately. Tyre builders making giant tyres are to continue reserved at 25, but those making small varieties are to be de-reserved on October 1 up to 30. Moulders of indiarubber will remain reserved at 25.

REVIEWS

"Technical Methods of Chemical Analysis" (Lunge and Keane's). Vol. IV: Second Edition. London: Gurney and Jackson. Price £4 4s.; pp. 963.

It is scarcely necessary to stress the importance of the volumes which comprise the work under the name of "Technical Methods of Chemical Analysis," written by the famous chemists, Lunge and Keane. They have become standard works for most industrial chemists in almost every branch of industry. The volume under review is of special interest to those analysts in the plastics industry, since one of the most important chapters deals with coal tar and tar products, and, in consequence, with the extraction, assaying and analysis of carbolic and cresylic acids. There is also a new and important section dealing with synthetic resin and other finishes. By far the greater part of synthetic resin stiffening of textiles is effected by urea-formaldehyde resins, since price, colour, odour, stability to alkali and resistance to detergents rules out most other resins. The condensation, defects and testing of these compounds are very adequately dealt with. There is an especially excellent section on "Resistance to Creasing" afforded by resins and in the tests carried out to evaluate this resistance.

"The Fire Protection and A.R.P. Year Book," 1941-42 Edition. Published by Lomax, Erskine and Co., Ltd., Aldwych House, W.C.2. Price 7s. 6d., post free.

The 1941-42 edition of the "Fire Protection and A.R.P. Year Book" makes a most opportune appearance this year in view of the numerous changes which the past 12 months have brought about in the Civil Defence services. It has been entirely revised and brought up to date to deal with these alterations, and much new information has been added increasing its usefulness still further.

The principal feature is the detailed statistical section giving, under 32 heads, particulars of the more important fire brigades throughout Great Britain and the Empire. This information includes, amongst other details, equipment and personnel, areas served, losses by fire, etc. Other sections contain comprehensive lists of the names and addresses of principal fire officers and A.R.P. officers, including recently awarded decorations. for gallantry during bombardments. Full details are given of the personnel and work of the many Government departments and Civil Defence organizations now in being. All have been revised to include the most recent changes.

Legislation affecting the Fire Service is dealt with in a series of articles, and a valuable new feature is the inclusion of a consolidated list of Statutory Rules and Orders still in force which bear on Civil Defence organization. The many new standards for A.R.P. equipment issued in the past year have been summarized, whilst numerous additions have been made to the miscellaneous section. An extremely comprehensive directory of suppliers of every type of A.R.P. and fire-fighting requisite and a full list of proprietary and trade names conclude this most valuable work.

The book, which runs to some 310 pages, is of a handy size, excellently bound in red cloth with gilt lettering, and no one who is connected in any way with the Fire Service or Civil Defence administration should be without a copy.

TRADE NOTES

Mr. H. R. Thurlow Prior has been elected chairman of **Lacrinoid Products, Ltd.,** in succession to Mr. Leopold Lazarus, and Mr. J. Geoffrey Hart has joined the Board.

Metaplast Hardware Co., Ltd., was registered on June 13, 1941, with a nominal capital of £1,000 in £1 shares. We understand that this company has been formed to develop the coating of plastics with metal films by electrodeposition.

Change of Address

Powder Metallurgy (1940), Ltd., inform us that the company has removed from Leadenhall Street to Commonwealth House, 1-19, New Oxford Street, W.C.1. Telephone, Chancery 6041.

Resinoids and Other Plastics as Film Formers

By B. J. BRAJNIKOFF, Consulting Electrical Engineer

One-time Consulting Engineer to the International General Electric Co., Inc., New York

1.—The Scope of the Coating Field: Films, Cements and Impregnants

THE term film-forming agent is meant here to designate, in its broadest sense, a fluid product, which, when spread over any surface, possesses the property of being able to be rapidly converted from a mobile phase into a solid state of coherent coating, or film, of plastic, strongly bonded to the base.

The degree of the mobility which is obviously necessary for the purpose of applying a coating medium is governed by the film-forming methods used, whether that be by brush, dip (impregnation), spray, roller or flow coat.

The development of a solid structure from the fluid phase may take place either at normal temperature and pressure by virtue of polymerization, oxidation and solvent evaporation, or it may be accelerated by the supply of energy in the form of heat, light or electrical irradiation.

The modern industrial age exacts a colossal demand for the products of coating media. Having regard to the almost infinite range of conditions under which the multifarious equipment has to function, it is not difficult to see that the qualitative needs of industry in coating compositions are practically endless.

For instance, the severe sphere of operations of aircraft, with its wide temperature fluctuations (say 60 degrees to −60 degrees C.) is dissimilar to that of sea and river-going vessels or railway and rolling stock. Very different from these are service conditions of installations in highly polluted atmospheres of factory districts, where the technical equipment, such as the chemical or electrical plant, is subjected to a ceaseless action of numerous destructive agencies.

In the circumstances it must be perfectly evident that there can be no one single coating medium whose superlative properties could meet all the diversity of needs, and, therefore, such a universal film-forming substance is beyond practical technology.

Advances in Our Knowledge of Resins

The last 10 to 15 years have been marked by exceedingly rapid developments in the use of various coating compositions derived from resins and cellulose esters.

Well-organized comprehensive researches, in which took part such eminent investigators as C. Ellis, Kienle, Carothers and others, led to evolution of a series of new ethers (e.g., ethyl benzyl, etc.), novel types of plasticizers and solvents, as well as to the discovery and introduction into the coating field of a number of the most valuable synthetic resins.

The fundamental merit and attraction of modern resinoids in the substitution for natural materials resides in the fact that, by enabling the scientific worker to build controllable molecules that combine characteristics required for a specific use, these products eliminate chance variation and thus relieve industry from its dependence on Nature.

The scale of manufacture and application of coating compounds based on synthetic resins in Great Britain, U.S.A. and in Germany has reached immense proportions and grows daily.

There is every reason to expect that the role and importance of resinoids as film-forming agents in the world's economic life, apart from pressing needs of a war period, will expand still further.

This will become even more apparent if we take into consideration the unprecedented magnitude of the reconstruction work which will have to be carried out in every industrial field at the termination of hostilities.

Impregnants

The basic function of coating media is to protect various materials, e.g., wood, metals, etc., from decay or corrosion by interposition of a continuous, inert and adherent film between the surface of an object and its environments, accompanied by the decorative effect of colouring and texture.

It should also be kept in mind that the utility of resinous solutions is not confined to surface functioning of varnish systems, lacquers and paints. Under well-defined conditions they form a very important class of impregnating media, with ever-increasing possibilities, for the treatment of various fibrous or absorbent bodies, such as wood, paper, textile fabrics and the like, thereby converting them into technical materials with exceedingly valuable physical, mechanical, chemical, dielectric, thermal and acoustic properties.

Cements

The resinoid media may also be used as adhesives and cements, hot or cold cured, for binding the most diverse substances, including wood, metals, paper, plastics, films, glass, porcelain, mica, etc., in the production of any type of composite materials, as, for example, laminated structures in sheet, rod or tube form, of outstanding mechanical strength and dimensional stability and chemical inertness.

Improved Wood

The behaviour of resinoid-impregnated wood under the influence of different physico-chemical forces has already been described by the author,[1] who in conjunction with his partner and friend, the late Professor W. E. Gibbs, conducted an extensive experimental research of fundamental nature on the subject at the Ramsay Laboratory of Chemical Engineering in the London University.

As a result of this and subsequent pioneering work, comprising all the principal impregnants of the phenolic and amino group of plastics (formulated and made by the author), and using the variety of timber species from different geographical zones, the writer was able to develop a series of technological processes for the treat-

ment of wood, which may be found of special benefit to a wide range of industrial applications, based upon a plant equipment of continuous type ensuring any scale of manufacture.

Utilization of Impregnated Wood

It may be pointed out that a greatly increased ability of resin-impregnated wood (either as a solid piece or the resinoid-bonded plywood) to resist the destructive effects of chemical action, absorption of solution, contamination of the product, shrinkage and swelling, abrasion, coupled with mechanical strength, renders it highly suitable material for the design of wooden plant equipment for the chemical process industries and allied requirements. The following uses are important:—Leakage-proof containers (vats, tanks, etc.), staves for tight cooperage (barrels, receptacles for acids, etc.), pipe and accessories, anti-corrosive lining for chemical works, panels, and material for laboratory furniture, sanitary and medical purposes, prefabricated portable houses, camp huts, and for interior and exterior application in many kinds of building construction.

It is important to note that the ultimate strength of timber by resinoid impregnation may be increased up to 300-500 per cent., as compared with an untreated specimen. For example, a typical breaking load for the natural beech in axial compression is increased from 6,000 to 19,000 lb. per sq. in. in the resinoid-treated piece, where by doubling its density (from sp. gr. 0.7 to 1.3) the strength is trebled.

By uniting the resin-impregnated laminæ of wood, as veneers in plywood (or by interposition of resin-treated paper between laminations), under heat and/or pressure, its mechanical fitness may be reinforced still further. By varying the number, thickness and specie of alternate laminations, as well as the direction of the fibres, and faced or backed by interlayers of metal, cork, felt, asbestos or any other combinations, the mechanical characteristics of resin-bonded structures can be modified at will.

The strength of bond can be made extremely great, and the adhesive power and durability of synthetic cements may be cited as conspicuous examples of this distinction; being chemically inert, fire-resisting and immune to attack by fungi and moulds, these binders, in the author's opinion, are far superior to such products as blood albumin, casein and many other types of glue, and merit preferential use in industry.

Hence, by virtue of its strength/weight ratio, non-corrodibility, water- and weatherproof qualities, this compound product (of any size and thickness, moulded to shape), due to its adaptability to rapid and inexpensive mass-production methods, promises to have a far-reaching effect upon many branches of technology, particularly in the chemical, electro-mechanical and architectural fields.

It yields an excellent substitute for valuable non-ferrous metals in engineering industries, as, for instance, in the manufacture of propellers, fuselage, spars, floats, hulls, and other members in aircraft, also in the construction of floors and sides of railway carriages, motor bodywork, etc.

Dielectric Features

By means of impregnating the wood with appropriate synthetic resins it may be transformed into an excellent insulator of high dielectric strength. As would be expected from a fibrous structure, the anisotropy of wood makes it impossible to obtain equal electrical characteristics in every direction, i.e., the longitudinal, the radial and the tangential.

A few of the basic points in the electrical performance of the resinoid-impregnated wood may be illuminated by the typical figures given below, as obtained by the author's tests[2]:—

The Behaviour of Resinoid-impregnated Wood as Dielectric.

Species	Beech	Spruce
Impregnants	Cresol/furfural + chlornaphthalene with alkaline catalyst.	Cresylic acid (xylenols)/furfural + chlornaphthalene with alkaline catalyst.
Dielectric strength KV/cm. at 20°C. after 48 hrs. in water*		
Mode of cut		
Tangential	128	122.5
Radial	125	119
Longitudinal	93.5	82
Permittivity	6.5	6.5
Dielectric losses (power loss factor) per cent.	0.05 at 20°C. 0.95 at 100°C.	0.08 at 20°C. 0.95 at 100°C.
Insulation resistance, megohms per cm. cube	5.5×10^4	5.5×10^4
Surface carbonization (by spark of induction coil)	Non-tracking	Non-tracking

* Test specimens: rectangular slabs 10 × 10 × 1 cm. of zero moisture content. Voltages at power frequency, 50 cycles per sec., sinusoidal wave-form.

The utility of the resin-treated wood for electro-technical purposes may be exemplified by the few following products, for which it is eminently suitable:—Supports for turbo-alternator windings, transformers, slot wedges, core spacers, barriers, brush gear bases for high-voltage d.c. traction motors; bushes, tension insulators, switch-operating rods for high voltage, switch handles, insulating stools, railway shoe beams, contact drums for controllers, erecting stands for accumulators, batteries, flooring, etc.; terminal boards, mounting blocks and boxes for switches, fuses, cutouts, relays, etc.; channelling and clips for cables, duct conduits, cleats, low-voltage wiring fittings, separators for cable blocks, radio cabinets, instrument cases, and numerous other articles.

The range of plastics available assures the choice of impregnating solutions to the best advantage of any object in view, and by controlling each operation involved in the impregnation process, viz., the resinoid compound, the temperature and pressure, as well as other factors, the properties of the resultant product can be standardized to suit any given purpose.

High-frequency Electrothermics

In this connection mention should be made of the possibilities that are opened up by the application of the high-frequency electrothermics in the plastics industry.

Whilst possessing definite advantages over the orthodox ways of curing the three-dimensional articles, the method is of special importance in dealing with the coating compositions.

The difficulties that are encountered in thermosetting of plastics predominantly originate from the problem of heat transfer through the body.

In consequence of the impeded heat transmission, due to poor thermal conductivity of the resinous constituents, various defects may develop within the product, such as non-uniformity of structure, case-hardening, blistering, etc., which, in turn, may impair its strength and other properties.

The action of high-frequency alternating currents of

the periodicity depending on the nature of a treated substance, through heating the latter by the dielectric energy losses or by induction, provides a very efficient means for rectifying the steep temperature gradient and thus ensures the uniform flow of heat throughout the system.

Indeed, since the films may be regarded, geometrically, as two-dimensional plastics, the performance of h.-f. electrothermic process is characterized by accentuated technological and economic effects of greatly accelerated drying and by the homogeneous setting of the coating medium and, therefore, larger output of better and cheaper products.

Having regard to the diversity of problems met with in practice, no general procedure can be formulated in the h.-f. electrothermic methods. For example, the heating by h.-f. currents of dielectrics and poorly conducting media should be carried out in the condenser field by using the radio periodicity up to the ultra-high frequency range of the order of $f = 10^8$ Hz (cycles per second).

The treatment of mixed systems, i.e., composed of dielectric media in which are dispersed metallic fillers in the form of powder particles or other electrically conducting agents, may be performed within a solenoid of appropriate design, whose field can be actuated by the currents of considerably lower frequency range than that required for dealing with the condenser field.

Applications

From the above it may be readily deduced that h.-f. electro-heating can be employed to advantage for expediting the rate of drying of enamelled metal articles, as, for example, mass-produced automobile and aeroplane bodies, wires, etc.

H.-F. method doubtless affords effectual means for the linking up of the plastics field with powder metallurgy for the development of composite products with improved or novel properties; for instance, the treatment of dispersed ferrous particles on resinoid medium may lead to the production of artificial magnets of elastic type; by combining various ingredients and fillers with different resinous media, the range of new materials with desirable features may greatly be extended, subject to laboratory research.

Furthermore, the h.-f. method can also be utilized for the drying of wood and other fibrous or granular bodies, vulcanization of rubber articles, for heating of chemical plant, and for drying in situ of various materials, particularly structural members in buildings affected by dampness, fungoid growth or moulds, and, finally, for the heat treatment of different foodstuffs (viz., tea leaves, preserving fruit syrups, melting of fats, and the like).

In the opinion of the writer, the h.-f. electrothermic method, in the development of which he has been interested for some time[3], invites the closest attention of scientific workers as a very promising and fertile field of research.

(To be continued.)

REFERENCES

(1) "*Ind. Chem.*," *VI*, 1930; *VII*, 1931. **(2)** "*Chem. Prod.*," *II*, *III*, 1939. **(3)** "*Plastics*," *I*, *II*, 1938.

PREFORMING WITH SYNTHETIC RESIN AS AN AID TO PRODUCTION

By P. L. Gossling

PREVIOUS articles in "Plastics" concerning the uses in synthetic resin moulding of special-purpose fillers, such as metal powders, recall a process which may be of interest to readers.

The idea, originated by Siemens-Halske of Berlin, and further developed by General Motors Corp., lies in the use of resin to assist in the production of certain articles when other methods would be either unsatisfactory or technically difficult. One application concerns the manufacture of ceramic insulators with exceptional insulating and refractory properties at high temperatures and pressures, the following being a description of methods employed.

The ceramic material, ground to the correct degree of fineness, is milled up with a relatively small proportion of uncured synthetic resin and then tableted, and moulded in ordinary presses to give a perfect moulding, a preformed insulator. At this stage, the insulator is strong enough to receive normal factory handling, but its physical properties are all far below standard. Also, dimensions of the insulator, although being geometrically a similar relation to those required in the finished state, exceed the latter by a predetermined amount, due to the resin inclusion and fairly large inter-granular spaces.

A low-temperature kiln firing, the next step, completely burns away the resin, leaving behind the moulded ceramic "filler," which, though unbonded, maintains its shape due to the intimate contact into which the grains were forced with each other when moulded with the wetting help of resin. However, the insulator now needs more careful handling, but can be filed or drilled, and is ready for the last operation, a high-temperature firing. This sinters the separate grains into one homogeneous whole, resulting in an insulator perfectly shaped with sharp contours, very consistent density and great mechanical strength, combined with the outstanding insulating refractory properties mentioned before.

As an essential of this process is the removal by heat of the resin after moulding, those materials can only be moulded which melt at higher temperatures than that at which the synthetic resin burns away. Such substances are clays, glasses and most metals; and therefore it is quite likely that the scheme could be applied to the large-scale production of some articles at present produced with difficulty in these materials by other means. In fact, this may already be the case, as a number of English, German and U.S. patents do cover certain applications of the process in specific instances.

Supporting Grids of Permali

An interesting new use of Permali, the resin impregnated laminated material made by New Insulation Co. Ltd., admirably demonstrates the value of this strong, light, yet completely inert, organic constructional material. The Permali is employed as a supporting grid for holding mixing vessels in a light alloy factory. It has been submitted continually to the action of milk of lime and hydrochloric acid without effect, thus simplifying the designer's material problem.

PLASTIC BEARINGS
and Sliding Surfaces in Machines

In This, the First Part of the Account, are Discussed Certain Fundamental Limitations of Plastic Bearings. Successful Trends are Noted

AFTER the main facts of design and operation of plastic bearings have been extensively discussed in a previous article*, it may be helpful, for the further introduction of this kind of bearing, to discuss experiences with various industries. It may be safely assumed that the bearing problem in every industry and in every machine is different, so that when one specific bearing material proves to be satisfactory in several places under varying conditions, more has been proved than might have been possible, even by extended investigations in laboratories under more or less ideal conditions.

No objection is brought against the use of laboratory tests for finding out the most suitable materials for given purposes, but really *practical* results may be secured only by extended *practical applications*, which may last for several months, or even several years.

Progress and Limitations

In the following discussion, based on the original reports, good and satisfactory results as well as defects and failures are noted. In many cases, service life is also given. These more or less non-scientific data may perhaps prove of more interest than long laboratory reports.

The use of plastics for sliding surfaces, circular and plain surfaces, are given. As in these instances sliding speed and the specific pressure are relatively low, even better results may be expected with plastics than in the case of the usual high-speed machine bearings.

General Remarks

In the first article, already referred to, no definite data on the loadability of plastic bearings could be given, except values based on results of investigations carried out under more or less ideal conditions. Their application in practice would necessitate a safety factor with regard to both speed and pressure. Recently some data on the loadability of simple closed plastic bushes with grease lubrication have been given (Fig. 1). Curves refer to bearings in continual use, A being for bearings with good heat dissipating powers, whilst for B a lesser capacity for dissipation is assumed.

The bushes may consist of a chipped textile material (type T2), laminated-fabric material (type T3), coarse-fibre laminated fabric (type G), or a fine laminated fabric (type F). The provision of simple lubricating means, and a design based on that of metal bearings, is presumed. The values given are, in fact, very low when compared with those yielded in laboratory tests (see "Plastics," October, 1939, p. 304) and may be considerably increased when applying a higher-grade grease, in the case of ample oil lubrication with interrupted service and in the case of special designs. The bearing length is assumed to be equal to 2 × shaft diameter.

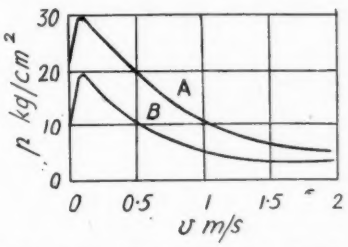


Fig. 1.—Loading curves for closed plastic bushes with grease lubrication. A, plastic with good heat-dissipating powers; B, plastic with lower heat-dissipating powers.

Fig. 2 shows the design of a commercially available split bearing moulded from chipped textile material (type T2). It is supplied in various sizes between $1\frac{3}{16}$ ins. to $4\frac{3}{4}$ ins. diameter by a continental manufacturer. The machining allowance for the bore is, for diameters up to 2.75 ins., 0.08 in. (2 mm.); for diameters above 2.75 ins., 0.12 in. (3 mm.).

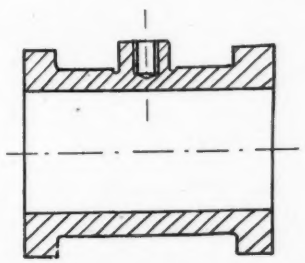


Fig. 2.—Commercially available split bearing moulded from Type T2 plastic with chipped textile filler.

Recently the press fit of plastic bushes has been investigated by Schwerdtfeger. As a result of his investigations, he is of the opinion that the press fit of plastic bushes can be calculated if, besides the dimensions, the properties of the material and a special specific factor, the "binding factor" (Haftbeiwert), be known.

Poisson's ratio for laminated fabric is the same as for steel, i.e., 3/10. Six months after the bush had been pressed in the pressure between bush and body was found to be reduced to about half of the original value.

Binding Factor in Practice

The tests showed that the binding factor was influenced by the roughness of the bore. It was found to lie between 0.05 and 0.1 in the case of metals. For bushes of a laminated fabric (type F), a binding factor of 0.42 was found for the pressing-in operation, 0.42 for their remaining in place and 0.34 for their shifting. The surfaces upon which these figures were obtained were merely turned, but in the case of ground surfaces lower values can be assumed. The forces for pressing-in are reduced when the bushes are placed in oil; this is now common practice.

Plastic Bearings in Rolling Stock

Application on any extended scale of plastic bearings to rolling stock, for instance, railway trucks, field railways, etc., seems somewhat remote, but, should it prove successful, it would mean great saving in metals and a means for reducing initial and maintenance costs. This has not yet been achieved, but after the first disappointing and disheartening results it has been found possible to obtain some quite satisfactory results by improved materials and designs. These justify the expectation that the problem of plastic bearings for this branch of engineering will be solved.

It cannot be expected that, in their present state of evolution, plastic bearings will prove satisfactory for high-speed locomotives and railway cars. This is confirmed by tests in the laboratory of the German State Railways.

During the first bench trials it was demonstrated that bearings made completely of plastics cannot be used for this purpose, as, besides their relatively

* "Plastics," 1939/3/304.

low strength, they have not the property of being able safely to run dry, in which circumstances temperatures up to 300 degrees C. may arise. An attempt to use a plastic layer in a bronze shell brought no advantage, as even at low speeds and loads very high temperatures were attained with danger for the safe running of the bearings.

Initial failures of plastic bearings for field railways in Germany led to an exhaustive study extending over a period of 1½ years. In this investigation 20 different brands of plastic bearings were compared with selected metal bearings, such as white metal, bronze, lead-bronze and special aluminium alloy.

The history of this investigation was as follows: The authorities dealing

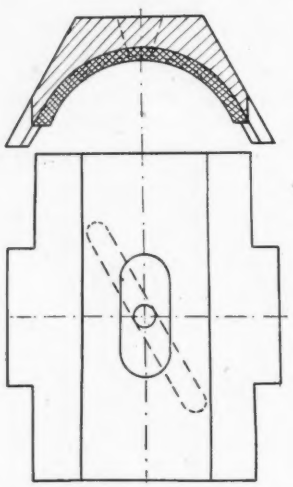


Fig. 3 (left).—Composite bearing consisting of trapezoid in forged steel, into which is pressed a plastic insert $\frac{3}{16}$ in. thick. Bearings constructed on this principle have proved highly successful in practice, the housing serving to strengthen the non-metallic liner and to function in some measure as a heat dissipating medium.

with metal supplies for the engineering industry prohibited, in October, 1936, the application of the usual metal alloys for many purposes, including rolling stock, in particular lorries and field railways of any description; for instance, dumping cars up to 6.6 cubic yd. capacity.

Forced Change to Plastics

This regulation would have necessitated the re-equipment with new bearings of about 100,000 cars in the building industry. Besides ball-and-roller bearings, which would require redesign of the existing axle construction, the only possible alternative lay in plastic bearings, which had proved a great success in the case of rolling mills. Under absolutely changed conditions, however, great difficulties very soon arose, and the ban upon metallic bearings in this connection was withdrawn for a considerable period.

Meanwhile, tests were started in which the bearings were tested under conditions similar to those in practice. These tests showed that, out of 20 different plastic materials, only two gave results broadly similar to those obtained with metal bearings; these were cresol-formaldehyde laminated resins wound in tube form, cured and afterwards ground to size. Material 19, for instance, had a 65 per cent. cresol-resin content with filler consisting of 35 per cent. cotton fabric and 20 per cent. cellulose wool. Material 20 contained 60 per cent. cresol-resin content with 40 per cent. asbestos-fabric filler.

For these tests a semi-closed bearing was used running under different loads (specific pressures) and speeds of rotation; coefficient of friction and the temperature of the bearing were determined during test. Examination of each material entailed six separate tests, run under increased speed and pressure until the bearing failed.

Hoffmann reports on "improved" cast-resin bearings, which, for cheapness, were not machined on the inside. Like other cast bearings of this kind, they did not prove satisfactory owing to their heat sensitivity and poor anti-friction properties.

A satisfactory solution to many problems has been found in bushes of malleable cast iron or soft steel (for taking the bending stresses, faced with a layer of plastic about 5/32-13/64 in. (4-5 mm.) thick, to provide good anti-friction properties.

The plastic is pressed direct in the bush and anchored by dovetail grooves. Bearing brasses previously used for babbiting can be used for plastic liners. Fig. 3 shows another type of such bearings with a trapezoidal bracket of forged steel into which is pressed a plastic insert of $\frac{3}{16}$ in. (5 mm.). The shaft diameter is 3 ins. and the bearing length 4.75 ins. (ratio l : d = 1 : 6). This bearing is suggested for a lorry of 5.22 cubic yds. capacity (4 cubic metres), whereas for lorries of 3.9 cubic yds. capacity (3 cubic metres) a shaft diameter of 2.75 ins. is provided.

Between 1926 and 1938 extended researches were carried out to develop the most suitable kind of bearings for the running wheels of railway containers of large capacity. The tests were carried out on a special stand designed to simulate practical conditions; seven different wheel sets were examined.

A shell of phenol resin with chipped textile filler was pressed in the wheel hub and rigidly fixed to the wheel by screws, i.e., it rotated with the wheel on the axle shaft (Fig. 4). In the middle of the hub a hollow space was provided for a larger quantity of grease than is normally used and was connected by a hole with the upper part of the hub; this hole, however, proved, later on, to be too small. The shaft was hardened, but no details with regard to bearing clearance are given in the original report.

Test Data and Results

The wheel set underwent five running tests; four under a standard load of 1,130 lb. (515 kg.) and one with a maximum load of 2,080 lb. (943 kg.). The temperature was

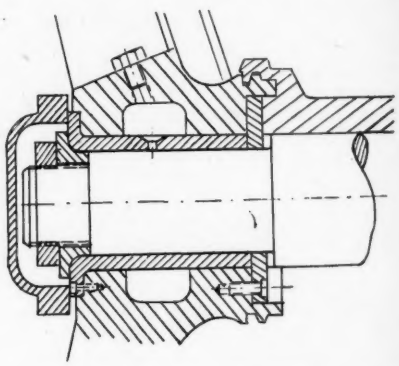


Fig. 4 (right).—Plastic bearing set-up developed to determine the suitability of plastic bearings for the running wheels of heavy duty railway containers (Germany). It should be noted that the lubricant supply was in excess of that used for metal bearings, the bearing running on a hardened shaft.

measured by a thermo-couple. The first three tests were carried out with pauses of half an hour and running periods of a quarter, a half and one hour, for total running periods of 2.5, 3.5 and 3 hours. The bearing temperature was controlled between 38 and 48 degrees C.

Endurance tests were carried out for 51 hours with a running speed of 7 m.p.h. (11.22 k.p.h.) at 346 lb./sq. in. The bearing temperature was not measured, but the bearing itself was found to be carbonized at the end of the test.

If we assume a bearing diameter of 2 ins. and a 3-in. bearing length, we obtain in these endurance tests a specific bearing pressure of 190 lb./sq. in. (12.5 kg./sq. cm.) and a rubbing speed of 89 ft./min. (0.45 m./s.). For the conditions noted above and at the maximum load of 2,080 lb. (943 kg.) in an endurance test extending to 77 hours, failure occurred in the same way. Up to 61 hours bearing temperature remained below 80 degrees C. and increased then to 200 degrees C. Cause of failure of these bearings seems to be too small a hole for the feeding of lubricant and to faults in design.

(To be Concluded)